N86-23097

HIGH PRECISION U-PB GEOCHRONOLOGY AND IMPLICATIONS FOR THE TECTONIC EVOLUTION OF THE SUPERIOR PROVINCE; D.W. Davis, F. Corfu, and T.E. Krogh, Jack Satterly Geochronology Laboratory, Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario. M5S 2C6

The underlying mechanisms of Archean tectonics and the degree to which modern plate tectonic models are applicable early in earth's history continue to be a subject of considerable debate. A precise knowledge of the timing of geological events is of the utmost importance in studying this problem. The high precision U-Pb method has been applied in recent years to rock units in many areas of the Superior Province. Most of these data have precisions of about ± 2-3 Ma. The resulting detailed chronologies of local igneous development and the regional age relationships furnish tight constraints on any Archean tectonic model.

Superior province terrains can be classified into 3 types:

1) low grade areas dominated by meta-volcanic rocks (greenstone belts).
2) high grade, largely metaplutonic areas with abundant orthogneiss and foliated to massive I-type granitoid bodies.
3) high grade areas with abundant metasediments, paragneiss and S-type plutons.

Most of the U-Pb age determinations have been done on type 1 terrains with very few having been done in type 3 terrains.

A compilation of over 120 ages indicates that the major part of igneous activity took place in the period 2760-2670 Ma, known as the Kenoran event. This event was ubiquitous throughout the Superior Province.

There is, however, abundant evidence for the widespread occurrence of pre-Kenoran volcanoes and sialic crust, especially north of the Wabigoon-English River subprovince boundary. In the Uchi and Sachigo subprovinces there are volcanic periods about 3000-2900 Ma (2,3) and 2850-2800 Ma (2,3) in age which underlie the Kenoran sequence. The Kenoran rocks are in part disconformable on the older sequences. The general absence of angular unconformities along with other evidence such as the presence of mature sandstones in the Sachigo subprovince (4), implies an extended period of crustal stability preceding the Kenoran event. Tonalites 2950-3200 Ma in age are found in the Favourable Lake (5), North Spirit Lake (3) and Winnipeg River Belts (6,7,8), suggesting a pre-Kenoran crust-forming event at about 3000 Ma. Evidence for the existence of an extensive pre-Kenoran continent is especially strong in the Winnipeg River Belt, a type 2 terrain. Recent data obtained from a type 2 terrain in the Wabigoon subprovince also indicates 3000 Ma volcanic and plutonic sequences (9). This indicates that type 2 terrains in many cases include pre-Kenoran crust, and that pre-Kenoran crustal material may be locally present in type 2 areas throughout the Superior Province.

The earliest Kenoran magmatism consisted of eruption of tholeiitic basalt platforms. These are difficult to date but in some areas pre-date 2750 Ma (10). Intermediate-felsic calc-alkaline volcanism occupied a time span from about 2750-2700 Ma and led to the construction of large composite volcanoes. The transition to calc-alkaline volcanism was associated with the emplacement of layered basic intrusions and contemporaneous tonalite-granodiorite plutons, without major deformation. This was followed by the intrusion of high alumina trondhjemite-granodiorite plutons, in some cases accompanied by later calc-alkaline volcanism. This resulted in the development of large intravolcanic batholiths (11). Significant regional deformation began relatively late, at about 2700 Ma over much of the Superior Province. In some areas, such as the Wabigoon greenstone belt, it significantly post-dated the bulk of calc-alkaline intrusive and volcanic activity (12).

Some greenstone belts underwent at least two periods of deformation. A D1 event affected the calc-alkaline sequences and pre-dated sedimentation and eruption of alkaline volcanic rocks (e.g. Tamiskaming sequence). The Tamiskaming-type sequences were then affected by a later deformational (D2) event. The ages of the late sequences and the D2 event are bracketed between 2695 and 2685 Ma in the southern Wabigoon and Shebandowan subprovinces (13), but may have been 15-20 Ma earlier in the Oxford Lake belt in the northern Superior Province.

The causes of regional deformation are unclear. It may have been partly the result of diapiric remobilization of the intravolcanic batholiths (e.g. Wabigoon greenstone belt), accompanied by regional compression, perhaps due to the intrusion of marginal late granitoid plutons (e.g. Batchawana belt) (14). The presence of nappe structures in some areas such as the Winnipeg River belt (15) and the southern Wabigoon subprovince (16) further complicates the tectonic picture. The final expression of strain was the establishment of large strike-slip faults, which often separate type 1 from type 2 and type 3 terrains.

The deformational event was accompanied by intrusion of late tectonic plutons, most of which have ages in the range 2700-2670 Ma (17). This resulted in cratonization and brought the Kenoran event to an end. Locally, single volcanic centers passed through this cycle from initial volcanism to terminal deformation in time spans as short as 30 Ma (18).

Although there is some indication of a secular younging in the peak of Kenoran igneous activity in a N-S direction, the broad simultaneity and short time spans of crustal events argue against any simple model for growth of the Superior Province by accretion of island arcs (19). Furthermore, there is a strong vertical control on magmatic and metamorphic ages. The oldest Kenoran plutons occur high in the crust while the youngest plutons and metamorphic ages are found at deeper crustal levels in more uplifted and eroded terrains such as the Berens River subprovince, parts of the Winnipeg River belt and the Kapuskasing structural zone (20).

Despite considerable work on the felsic units in type 1 greenstone terrains, there is almost no evidence of inherited zircon components derived from significantly older sialic material. The intravolcanic granitoid rocks and thick felsic volcanic sequences were largely derived by differentiation processes from mafic precursors within the period of Kenoran activity (11). However, greenstone belts evidently did develop adjacent to older sialic blocks. Evidence for this, found in the Wabigoon greenstone belt, includes pre-Kenoran granitoid clasts in a conglomerate marginal to the belt and the existence of marginal unconformities between 3000 Ma tonalite in the Winnipeg River belt and Kenoran volcanic and plutonic sequences (7). Abundant mafic dykes intrude the older units below these unconformities and indicate a tensional stress regime.

The bulk of the evidence presently available argues for a model in which greenstone belts were initiated by rifting of older sialic crust and the formation of narrow ocean basins. The fault controlled nature of many subprovince boundaries as well as the fact that volcanism was at times nearly coeval throughout the Superior Province suggests that rifting may have been concentrated along major early lithospheric breaks.

Evidence for subduction in late Archean tectonic processes is missing. The absence of an effective subduction mechanism would have inhibited ocean spreading. If the intracratonic rifts were not able to open into wide ocean basins they would have been reworked in place, undergoing dominantly vertical tectonic processes. Continued mantle-derived mafic magmatism may have led to thickening and differentiation of the crust to produce the large amounts of calc-alkaline material now present in type 1 terrains.

Any model for tectonic development can only be tentative and subject to the constraints of a constantly expanding data set. Some of the major questions remaining for geochronology are the extent in time and space of pre-Kenoran material and its deformational history and the origin and basement of the metasedimentary belts. These questions can only be resolved by much more extensive work in type 2 and type 3 terrains.

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